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AN EXAMINATION OF THE RDA BRIEFING

"LATE-TIME NUCLEAR DUST-CLOUD ENVIRONMENTS. AN EMERGING ISSUE FOR AIR-BREATHING VEHICLES (U)"

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EXECUTIVE SUMMARY

The issue of nuclear dust being a threat to strategic aircraft has been raised by RDA. Their briefing (attachment 4) supports this by drawing an analogy to the recent Mt. St. Helens eruptions and resulting aircraft incidents. This paper deals with the RDA's primary concern, engine damage tolerance. Though preliminary, it gives a feel for how the key ingredients of particle size, density and engine debris ingestion interact.

Review of the Mt. St. Helens aircraft incidents revealed only one serious engine ingestion problem, that of a L-100 turboprop (C-130 variant) which encountered heavy volcanic dust concentrations after the first eruption.

Engine debris ingestion, of any type, requires a definition of debris size and density vs time. Once defined, those values can be compared against the aircraft engine's specification for ingestion tolerance. All of the current strategic aircraft engines analyzed were found capable of withstanding the RDA predicted levels of nuclear dust size and density (assuming the aircraft avoided all nuclear debris for at least 15 minutes after detonation). The AGM-86B ALCM engine during actual sand ingestion testing, was able to pass specification levels after ingesting twice the specified sand density levels.

The mission limiting ability of airborne nuclear debris requires further investigation. The uncertainly of airborne debris density is sufficient cause to establish procedures to avoid a known dust cloud area. Other areas such as damage to electro-optical viewing systems and air crew radiation tolerance to flight cabin ingestion of nuclear dust need to be addressed.

1. INTRODUCTION

The RDA briefing, "Late-Time Nuclear Dust-Clouds Environments", Attachment 4, surfaces a possible threat to strategic aircraft. The impact of nuclear blast generated dust clouds on strategic aircraft may be analagous to recent aircraft difficulties with the Mt St Helens volcanic ash clouds. The implication is that large scale nuclear surface bursts will create a "harsh, operationally limiting, environment for aircraft". Literature searches reveal that long term nuclear debris has neither been well investigated nor documented. Additionally, the information gathered on the Mt St Helens eruption, Attachment 3, leads one to the conclusion that the aircraft related incidents have not been integrated into scientifically usable data. The nuclear debris issue requires detailed research into: (1) particle density, size, and location vs time, (2) probability of dust cloud encounter, (3) engine damage tolerance, and (4) crew resaretance. The density, size, location, and time aspects are particularly difficult due to lack of adequate analytical tools. Nevertheless, this paper provides some insight into the interaction of the topic's key drivers.

2. BACKGROUND

The issue of dust clouds affecting strategic aircraft arises from the recent Mt St. Helens eruptions. Therefore, it's appropriate to make some comparisons with a nuclear blast and review the resulting aircraft incidents.

Three characteristics made the Mt St. Helens eruption unique from a nuclear burst. First, the mountain's altitude in effect created a surface burst at 10K ft. This injected debris higher into the atmosphere and influenced the rate at which particles settled out. Second, the magnitude of the blast, which was in the 10s of megatons range, caused a much greater amount of debris to be ejected than a nuclear blast in the one megaton range. Third, as described in Attachment 2, the composition and behavior of the volcanic dust cloud can be quite different from a nuclear dust cloud depending on the nuclear yield and burst altitude. Considering the above, a review of Mt St. Helens related aircraft incidents revealed the following:

a. A Transamerica Airlines L-100 (C-130) departed McChord

AFB, Washington, on 25 May 80 bound for Travis AFB, about three hours after a St. Helens eruption. On departure, the aircraft requested radar vectors to avoid the Mt. St. Helens area, but the request was denied due to other traffic conflicts. Climbing through 11,000 feet, the aircraft encountered a heavy concentration of ash. Immediately, two engines malfunctioned and had to be shutdown. The aircraft returned to McChord AFB after a total flight time of about 22 minutes. Inspection revealed that all four engines were damaged and had to be replaced. It was discovered that engine damage was caused by a build up of silica deposits (1/8 to 3/16") on the turbines and temperature probes as well as erosion of the compressor case lining. The buildup of deposits reduced airflow through the engine and this caused erroneous temperature sensing thus causing the engines to surge and burn out their turbines. Investigation also revealed that all leading edges on the aircraft were frosted by the ash, but no structural airframe damage occurred. Furthermore, there appeared to be no adverse effect on the engine bearings, engine oil, fuel system, or electrical system.

b. A Hughes Air West DC-9 encountered some of Mt St. Helens dust while flying at 35,000 feet. The aircraft received only minor damage and no formal report was made. The volcanic ash polished the leading edges and resulted in the windshields having to be replaced. Inspection found nothing wrong with the engines. However, the oil and filters were changed as a precautionary measure.

c. Two Braniff 727s flew through light concentrations of ash dust from Mt St. Helens. Initially, it was reported that both aircraft suffered seizure of the midspan shrouds in all three engines, and that the engines were replaced. Further investigation revealed that the two aircraft experienced no difficulty in flight, and that most of the problems occurred on the ground following the flight. The Fort Worth FAA office reported that the Braniff maintenance people used water to clean the compressor section and drove dust into the root section, thus freezing up the blades. Initially, two engines were removed, but later replaced when the chief engineer determined that the dust could be blown out with high pressure air. The FAA indicated that the Braniff aircraft suffered no detrimental effects, and that they were not concerned over the effects of the dust after receiving the Braniff reports.

d. Reports indicate that the search and rescue aircraft performed remarkably well in the Mt St. Helens environment due to the extraordinary maintenance procedures that were used to clean the aircraft following each flight .

e. The NASA Ames Research Center used U-2 aircraft to penetrate the ash plume the day after the eruption. No problems were encountered. However, a major inspection will be performed on the engines to look for any unnoticed damage.

f. B-52s/KC-135s out of Fairchild AFB experienced no increase in engine failures or related components while operating in a dust environment.

It seems significant that given the magnitude and altitude of the eruption that only one aircraft reported significant problems with the dust cloud. It is not clear what unique combinations of dust and other influencing factors caused the L-100 incident.

3. ANALYSIS

Aside from the Mt. St. Helens incident, the possibility of a massive surface burst attack on the US may present a long term threat to the strategic force. A preliminary feel for the problem requires estimating the debris particle size environment versus time, determining ways of avoiding debris clouds, and failing that, estimating whether or not encountering the debris clouds has a mission limiting effect on strategic aircraft.

The principal engineering concerns in encountering nuclear debris are particle size and density. In a post attack environment airborne particle size will decrease with time and dust cloud expansion. The RDA briefing indicates that for a given time period and altitudes of interest, i.e., 0-30K FT, the particle size and density are fairly uniform. Using RDA values, a composite curve can be drawn (figure 1A) to give an idea of what size particles strategic vehicles might encounter in the post-attack period (Figure 2 gives a visual comparison of the sizes). Against the time progression, representative timelines are drawn for the strategic aircraft of interest (figure 1B). It should be noted that the curve shown can be repeated with subsequent attacks; however, for this analysis only a first exchange is considered.

During base escape and flyout (0-3HR), aircraft will avoid likely blast areas as well as those detected by onboard sensors. Debris will be a secondary problem compared to nuclear effects, i.e., gust, blast, thermal etc., since the sure-kill range of those effects will reach out farther than the blast ejecta. To penetrate the debris area would require passing overpressure levels far in excess of the limit for any current aircraft. Dust clouds at high altitudes will be fully developed at 3 hrs (per RDA) after a massive attack. Tankers and CMCAs returning to CONUS may encounter suspended particles of 40 um size for 2-4 hrs while reaching a recovery base. The penetrators (9-15 hrs) will possibly encounter US generated debris from ICBMs, SLBMs, ALCMs, and other penetrator attacks. US ICBM attacks should generate debris along a timeline similar to figure 1A. Nuclear debris from other incountry weapons, i.e., ALCMs, SRAMs, etc, should be avoided in a manner similar to base escape and flyout. ALCMs could encounter U.S. generated dust on the order of 40 microns

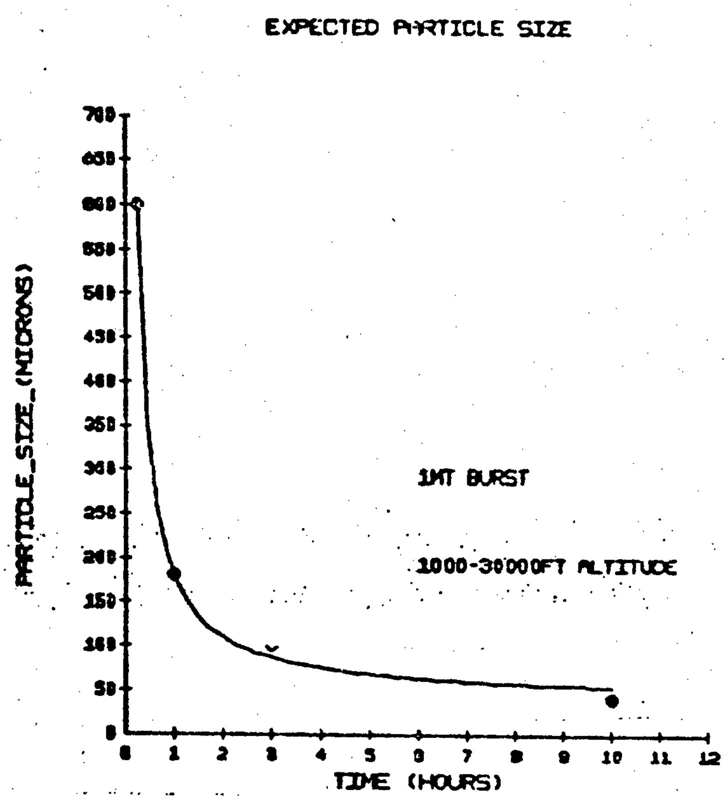


FIGURE 1A

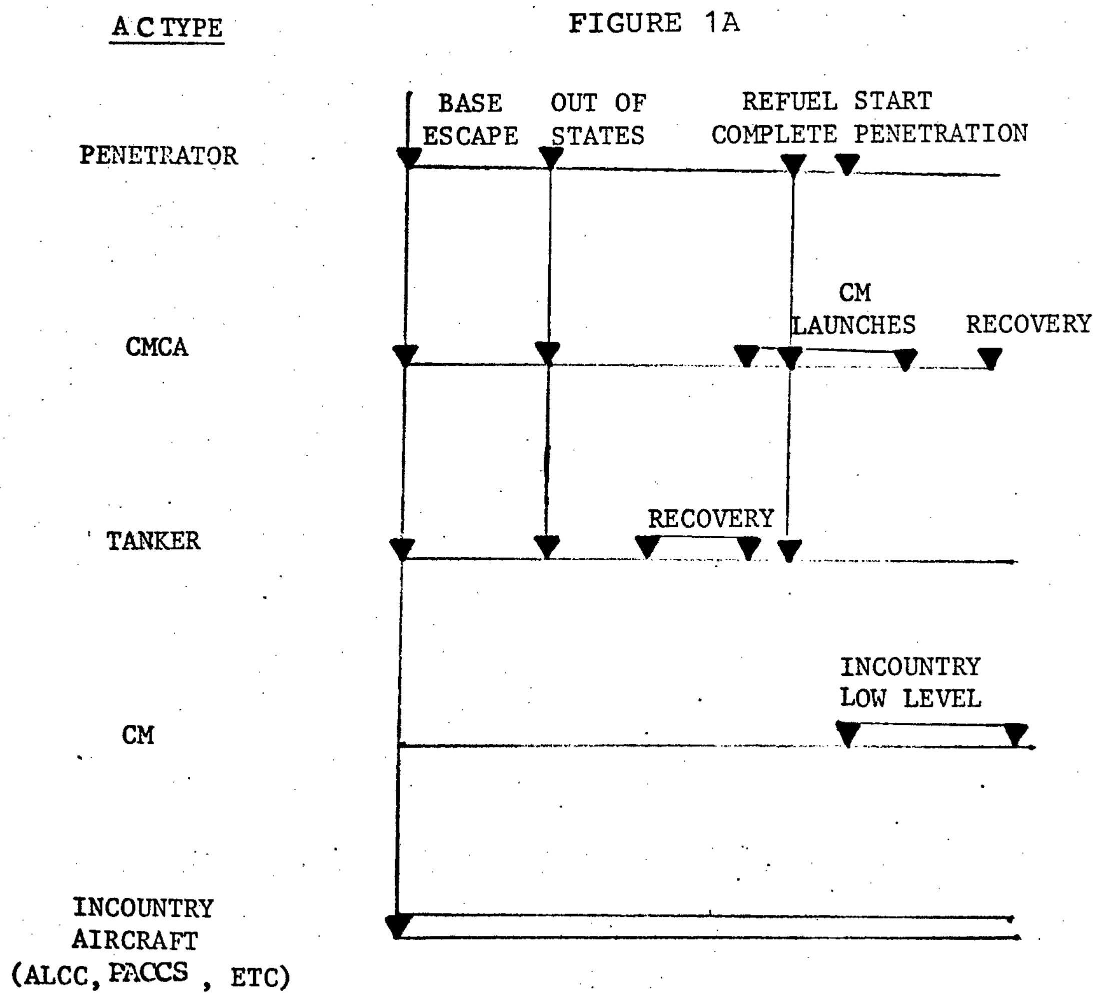
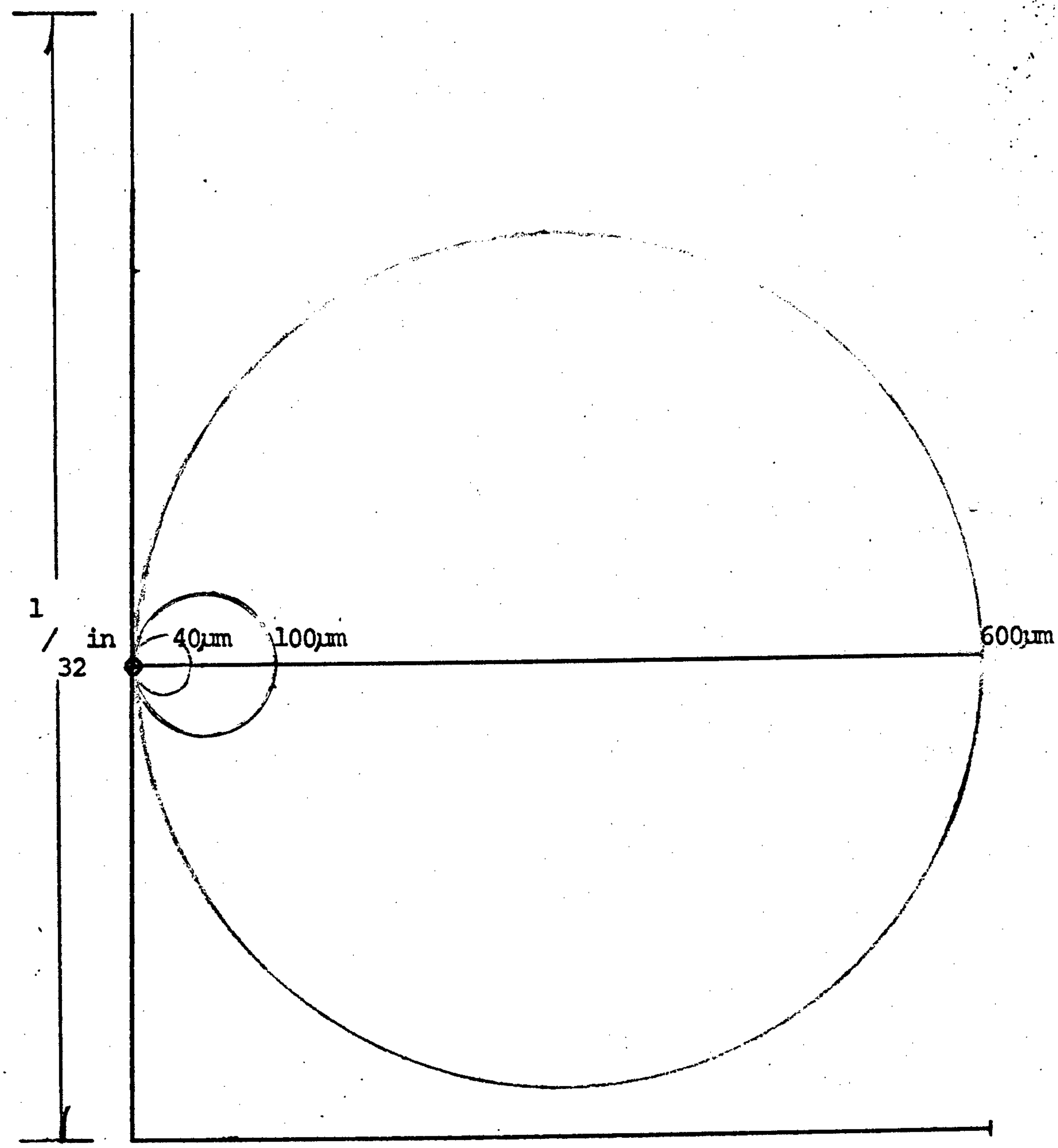


FIGURE 1B



$$1\mu m = \frac{1}{1000000} \text{ meter}$$

FIGURE 2

for up to 3-4 hours. Sensor detonated debris, i.e., land mine type, would require independent analysis. Incountry U.S. aircraft (ALCC, etc.) would contend with nuclear debris areas for the entire post attack period. Those aircraft will face the longest possible exposure to potential debris damage.

The discussion so far indicates that nuclear dust debris could be encountered and be as large as 600um . This assumes that aircraft avoid nuclear debris for 15 min (figure 1A). Encountering nuclear debris will affect windshields, wing leading edges, radomes, and engines. The first three should be highly resistant, since they have more stringent design requirements. Estimation of the ability of various engines to withstand dust cloud densities 15 min, 3hrs, and 10 hrs post attack is described on page 3 of Attachment 1. The bottom line is that dust density level is the key variable. At sufficiently high density levels, engines may ingest enough debris per second to exceed design specification levels. However, analysis shows that for the density levels predicted by RDA, none of the engines exceeded sand ingestion specification levels. Also, at density levels an order of magnitude greater, the spec levels are exceeded only for particle sizes greater than 600um and for less than 15 minutes post attack.

4. OBSERVATIONS

The following conclusions and observations are given:

a. The strategic implications of aircraft encountering Mt St Helens ash are nebulous. Better documentation of aircraft flights through the Mt St. Helen's affected airspace is needed in order to determine the statistical significance (if any) of aircraft encounters with dust. All incidents, no matter how minor, should be accurately recorded in order to establish cause-effect patterns. This service could be provided by the FAA with assistance from the National Weather Service and MAJCOMS.

b. The Mt St Helens experience does show that airborne debris will frost windshields. While this is not a problem in a closed cockpit, it may be a problem with the B-52 electro-optical viewing systems.

c. If forced to fly through nuclear debris clouds the pilot might be able to circumnavigate the dust cloud after detection. Figure 3 shows the line of sight detection range of a dust cloud at 30K FT for an aircraft at varying altitudes. As shown, the values are given in a band with the upper limit being perfect line of sight. The lower limit might represent the decreased decision time due to weather, terrain, or other crew workload duties. Even at 70% of optimum line of sight, an aircraft at sea level has 20 minutes to detect and avoid a nuclear cloud. This number goes up to 40 minutes if the aircraft

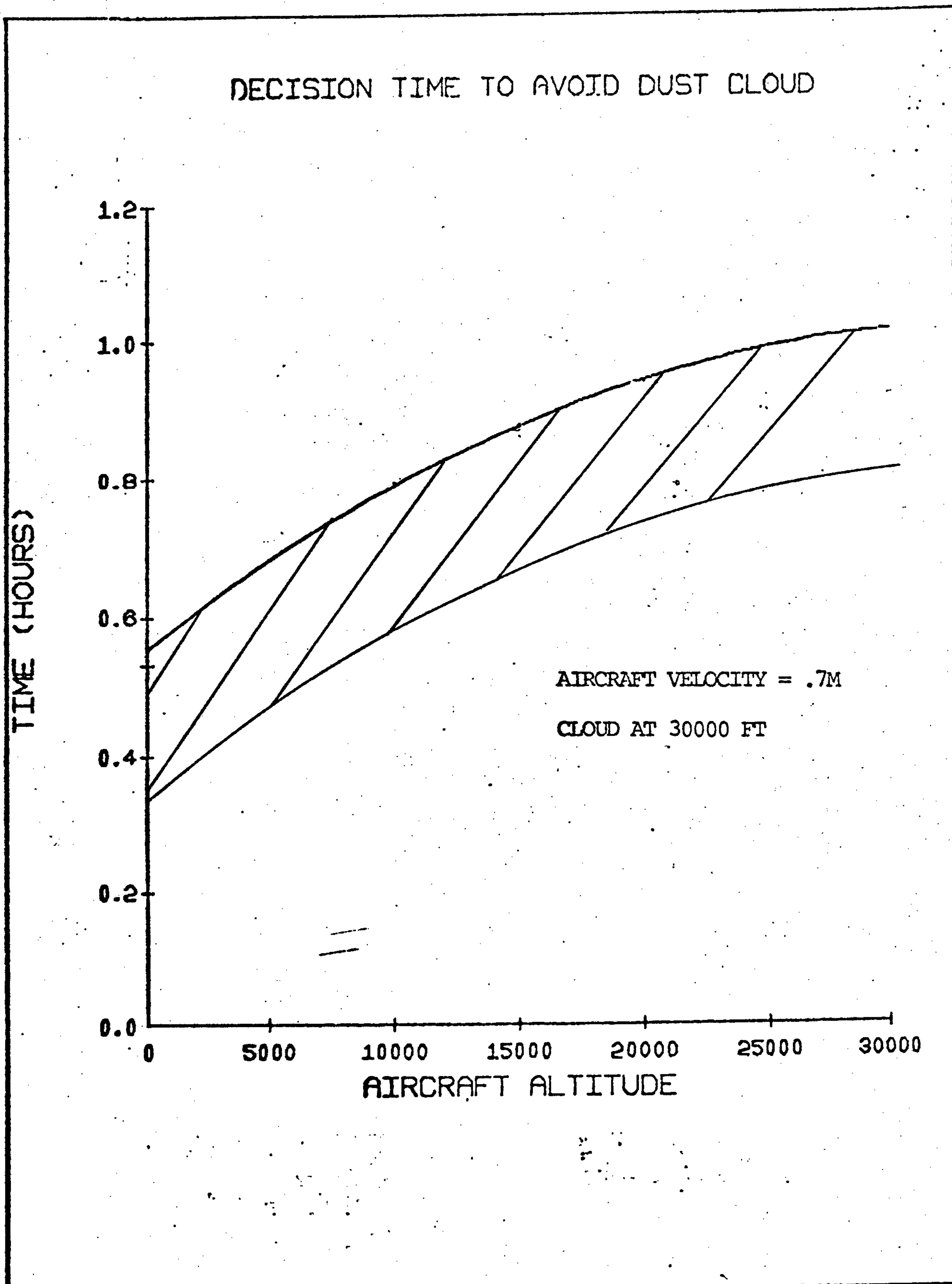

DECISION TIME TO AVOID DUST CLOUD
TIME (HOURS)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
5000
10000
15000
20000
25000
30000
AIRCRAFT ALTITUDE
AIRCRAFT VELOCITY = .7M
CLOUD AT 30000 FT

FIGURE 3

is co-altitude with the cloud. Twenty to forty minutes should be adequate to provide alternate routing.

d. If penetration of the dust cloud is unavoidable, i.e. EWO timing constraints, then aircrews could adjust configuration, airspeed, or altitude to reduce the detrimental effects on the aircraft. Future design innovations in filters and inlet designs may offset some of the problems associated with dust ingestion.

4 Attachments
1. Estimate of Engine Durability Against Nuclear Dust Cloud
2. Volcanic and Nuclear Dust Comparison
3. Sources of Information
4. Late-Time Nuclear Dust-Cloud Environments

Estimate of Engine Durability Against Nuclear Dust Cloud

Issue: What is the durability of various aircraft engines to a nuclear dust cloud of given density versus that implied by the military specification for sand ingestion?

Per MIL-E-5007-D: An engine must be able to ingest 1.17×10^{-10} pounds of SAND/CM^3 for 10 hours (.5 hours for ALCM) with less than 5% loss in performance. Engine is running at max power for entire time, except for one throttle cycle to idle each hour (every 10 minutes for ALCM).

In order to evaluate engine durability it is assumed that the engines are at 10KM (33K ft) altitude on an aircraft flying 2.1×10^4 CM/sec. (.7M) (.65M at sea level for ALCM). These velocities are conservative compared to the max power condition in the spec.

The following equation gives an estimate of the number of particles/second (P/S) an engine would ingest per the specification.

$$P/S = \frac{(1.17 \times 10^{-10} \#sand/cm^3)\ (V)\ \ (A^*)}{\#/P}$$

where:

P/S = particles/second

V = velocity = 2.1×10^4 CM/sec (2.21×10^4 CM/sec [ALCM])

A* = engine inlet area (CM^2) that ingests sand. This number is less than the total engine inlet area. For turbojets it takes into account interference from the compressor blades. This interference, which limits debris ingestion into the turbine section, is less an effect at extremely

small particle size (40 microns). For turbofans it includes interference plus the centrifuge effect caused by the bypass airflow.

$\#/P$ = pounds/particle = r^3 (2.04×10^{-14})

where: r = particle radius in (um).

Assuming a 40 um (dia) particle the equation becomes:

$$P/S = \frac{(1.17 \times 10^{-10})\ (2.1 \times 10^{4})\ (A^*)}{1.63 \times 10^{-10}}$$

- the "spec" levels for various engines are:

			"SPEC" LEVELS P/S (10^5)		
AIRCRAFT	ENGINE	A* $(10^3 CM^2)$	40 MICRON*	100 MICRON*	600 MICRON***
B-52G	J57	6.97	1050	66	.32
B-52H	TF33	7.43	1119	70	.35
KC-135A	J57	6.97	1050	66	.32
KC-135R	CFM56	13.0	1959	122	.61
ALCM	F107	.364	57	3.6	.018

* $\#/P = 1.63 \times 10^{-10}$ lb ** $\#/P = 2.6 \times 10^{-9}$ lb *** $\#/P = 5.5 \times 10^{-7}$ lb

The following equation gives the P/S for a particular density nuclear dust cloud.

$P/S = (V)\ (A^*)\ (\sigma_p)$

where: P/S, V, A* are as before

σ_p = particle density = $\frac{\text{particles}}{CM^3}$ (40 um = $5 \times 10^{-3} P/CM^3$) (100 um = $1.3 \times 10^{-3} P/CM^3$) (600 um = $6.4 \times 10^{-5} P/CM^3$)

The value for σ_p is the driver in the equation. Discussions with people working the area indicate that the σ_p value may vary by an order of magnitude. This is due to the nonuniformity of the cloud and overlap of adjacent debris clouds. Figure 4 plots P/S versus σ_p for 40 μm, 100 μm, and 600 μm diameter particles respectively. These diameters approximate the cloud fallout particle size 10 hours, 3 hours, and 15 minutes post attack. As shown, the RDA predicted 40 & 100 micron levels of σ_p give values of P/S below the "spec" levels previously calculated. At the 600 micron level of σ_p, the particle density present is below spec levels. However, an order of magnitude greater σ_p surpasses the "spec" levels for all aircraft.

Insight into what would happen if orders of magnitude greater density debris were ingested is given in figure 5. Shown are ALCM data similar to the aircraft plots in figure 4. An interesting aspect of the ALCM sand ingestion test was that twice the specification required sand density was ingested. The result was a 3% decrease in thrust and a 4% increase in SFC. This is less than that required by the specification. As the figure 5 shows, this inadvertant increase in sand ingestion is almost three orders of magnitude greater than the predicted RDA density level. The implication is that larger turbofans and turbojets with their greater tolerances would have a similar resistance to greater sand ingestion densities.

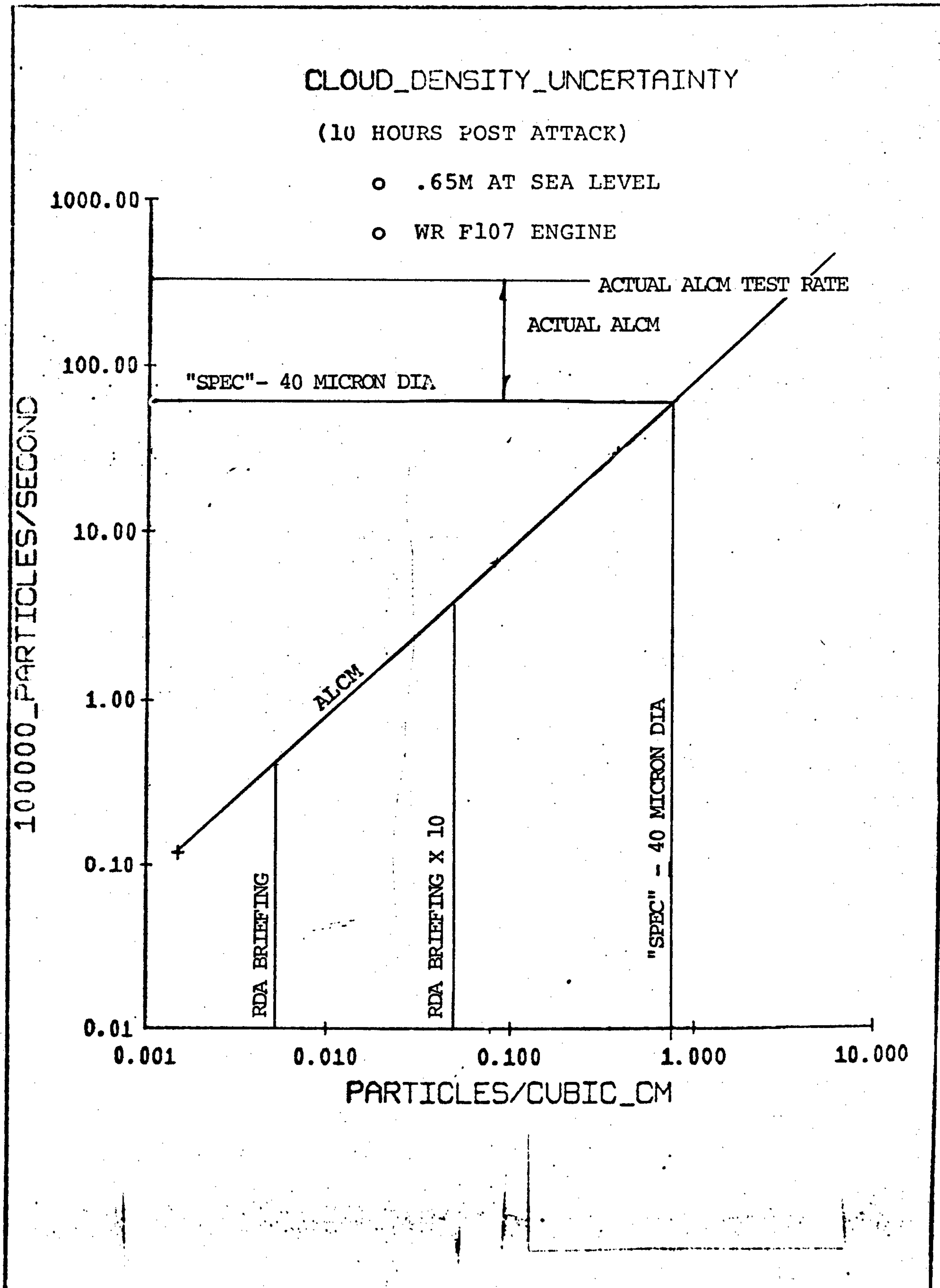

CLOUD_DENSITY_UNCERTAINTY
(10 HOURS POST ATTACK)
o .65M AT SEA LEVEL
o WR F107 ENGINE
ACTUAL ALCM TEST RATE
ACTUAL ALCM
"SPEC"- 40 MICRON DIA
ALCM
RDA BRIEFING
RDA BRIEFING X 10
"SPEC" - 40 MICRON DIA
1000.00
100.00
10.00
1.00
0.10
0.01
100000_PARTICLES/SECOND
0.001
0.010
0.100
1.000
10.000
PARTICLES/CUBIC_CM

FIGURE 5

VOLCANIC AND NUCLEAR DUST COMPARISON

VOLCANIC DUST	NUCLEAR DUST

COMPOSITION

Volcanic dust:

SILICON - 60%	TITANIUM
ALUMINUM - 16%	SULPHUR
POTASSIUM	CHLORINE
CALCIUM	FLUORIDE
IRON	SULFURIC ACID
COPPER	CHLORIDE SALTS + ACIDS
OXYGEN	

Nuclear dust:

SOIL - BASED DUST
DEPENDS ON TYPE
OF SOIL (e.g. CLAY, SAND, ROCK)

ABRASIVENESS

HIGH

HARDNESS

APPROX 6 (ON MOH SCALE)

ACIDITY

GROUND: PH 5.2 TO 6.8
55 - 65M FT: PH 2.0

TOXICITY

Volcanic dust:

UNCERTAIN:
NOTHING IN MEDICAL LITERATURE
ON HEALTH EFFECTS OF VOLCANIC ASH
- 50% OF ASH IS RESPIRABLE
- HIGH CONCENTRATION OF CRISTOBALITE WHICH IS LARGELY RESPONSIBLE FOR SILICOSIS

Nuclear dust:

RADIOACTIVE

PARTICLE SIZE

Volcanic dust:

- 5 TO 100 MICRONS
- 100 NM FROM ST HELENS

<5 MICRONS	70%
5-15	28
15-25	1.4
25-50	0.3
>50	TRACE AMTS

Nuclear dust:

LOW RANGE 0.1M TO 1.0M
HIGH RANGE 10^3M TO 10^4M

ALTITUDE

Volcanic dust:

DUST UP TO 23KM (71M FT)
REPORTED

Nuclear dust:

YIELD (MT	CLOUD HEIGHT (KM)
0.1	12
1.0	18
10.0	28
100.0	33

VOLCANIC DUST		NUCLEAR DUST
	PATTERN	
COMPLEX/UNPREDICTABLE		COMPLEX/UNPREDICATABLE
	AREA	

Volcanic dust:

TIME (SEC	AREA (CM^{2}M)
10^3	10^{14}
10^5	10^{16}
10^6	10^{17}

Nuclear dust (1MT):

TIME (SEC)		AREA (CM^2)
10^3		10^{13}
10^5	(1 DAY)	10^{15}
10^6	(10 DAYS)	10^{16}
10^7	(100 DAYS)	10^{17}

EFFECTS

Volcanic dust:

- WINDSHIELDS - PITIED
- ENG.BLADES - ERODED AND COATED WITH SILICA
- CONTAMINATION OF AIRCRAFT SYSTEMS
- EFFECTS NOT WELL TESTED OR DOCUMENTED

Nuclear dust:

- ASSUMED TO BE LESS ABRASIVE THAN VOLCANIC SILICA DUST
- AIRCRAFT CONTAMINATION
- EFFECTS NOT WELL TESTED OR DOCUMENTED

SOURCES OF INFORMATION	SUBJECT
FAA Regional Centers Seattle San Francisco Oakland Phoenix Ft Worth	Status of aircraft that penetrated Mt. St. Helen's dust clouds.
FAA, Washington, D.C.	Advisory Circular on Volcanic dust Upper Atmospheric Program Bulletins
General Electric	GE engine spec data and ingestion test reports
Pratt & Whitney	P&W engine spec data and ingestion test reports.
Allison	Allison 501-D22A engines
RDA	Nuclear Dust Environments
SAI	Particle Size Distribution
DNA	Nuclear Dust Environments
Transamerica	Status and report on Transamerica L-100 aircraft

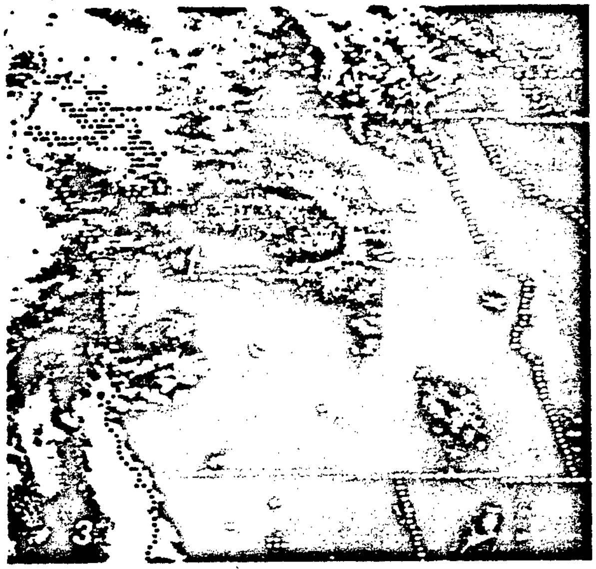
SOURCES OF INFORMATION	SUBJECT
McChord AFB	Command Post and Transient Maintenance impressions of the L-100 encounter with volcanic dust
SAC/LGMSB	Status of SAC aircraft involved in Mt St. Helen's incident
AF/LEYY	Air Force dust procedures used during Mt St. Helen's incident
JCMPO	Cruise missile ingestion test
Aviation Weekly	Mt St. Helen's eruption
ASD/YZ	Aircraft engine sand ingestion spec MIL-E-5007-D
NAVY AERO PROPULSION CENTER	Sand ingestion testing on the WR-F107-cruise missile engine

LATE-TIME NUCLEAR DUST-CLOUD ENVIRONMENTS

AN EMERGING ISSUE FOR AIR-BREATHING VEHICLES

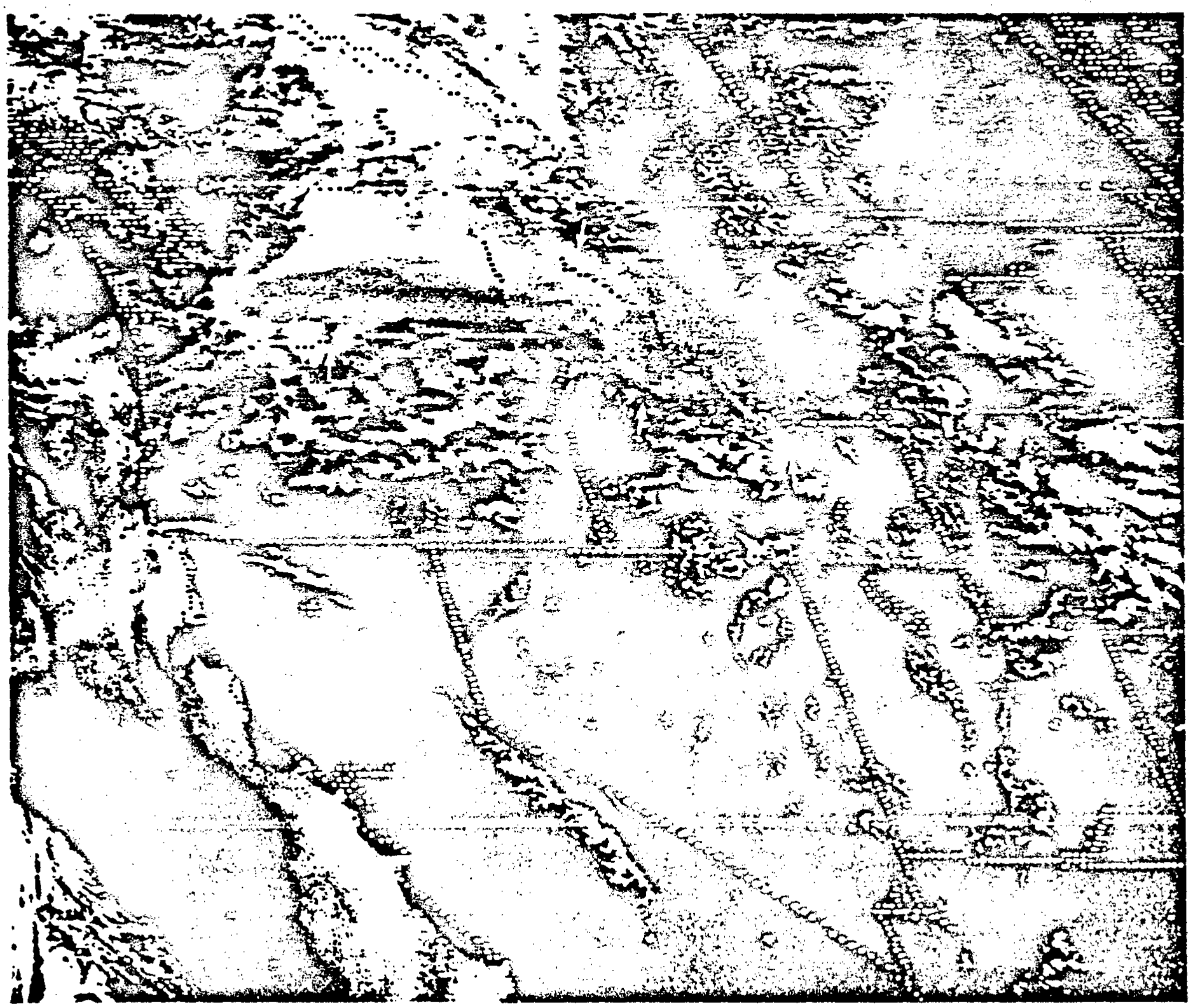
R & D ASSOCIATES
Post Office Box 9695
Marina del Rey,
California 90291

VOLCANIC ERUPTION DISRUPTS AIR TRAFFIC

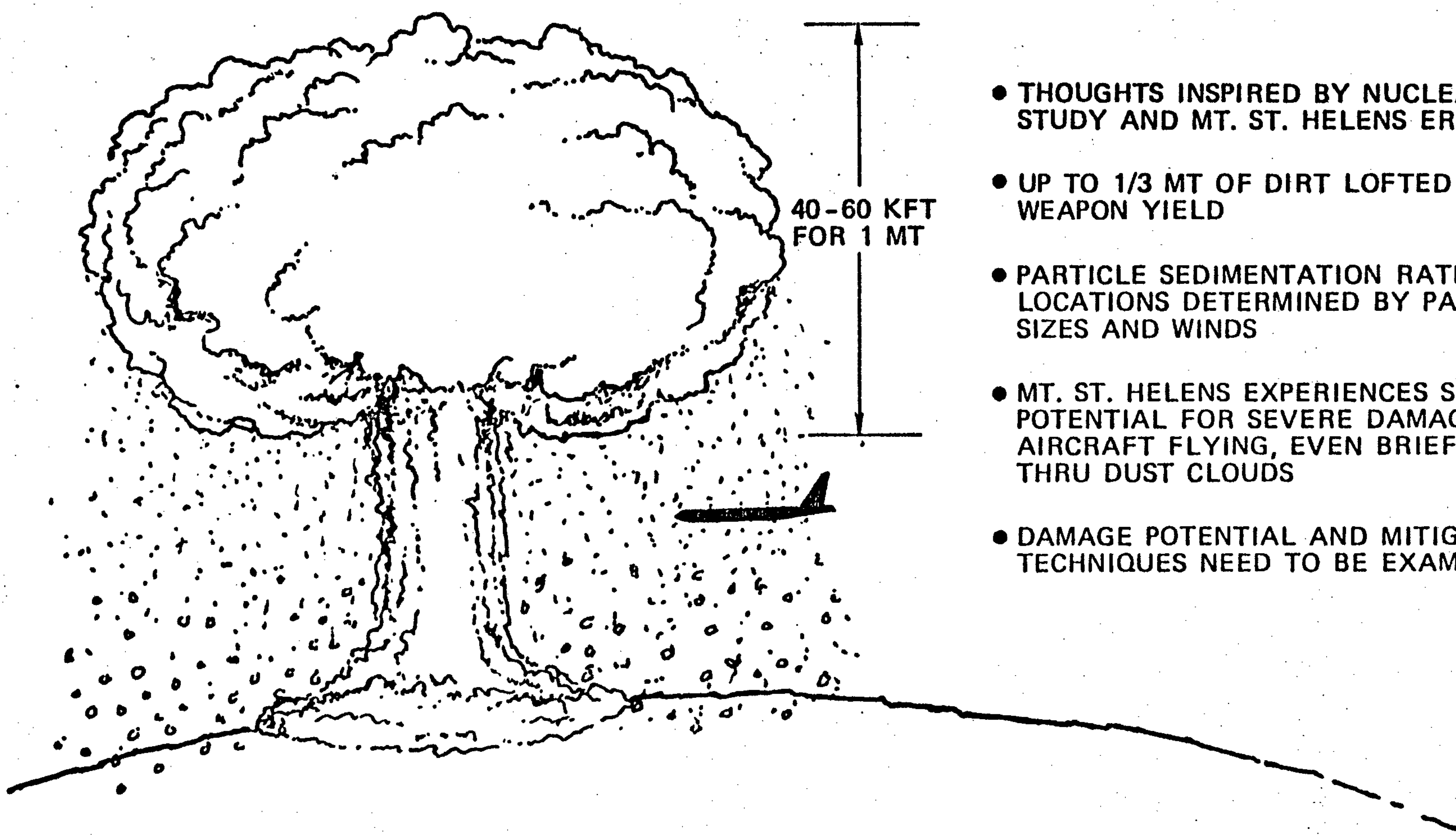


VOLCANO CONTINUES TO SNARL AIR TRAFFIC

MANUFACTURERS ISSUE VOLCANO ADVISORIES

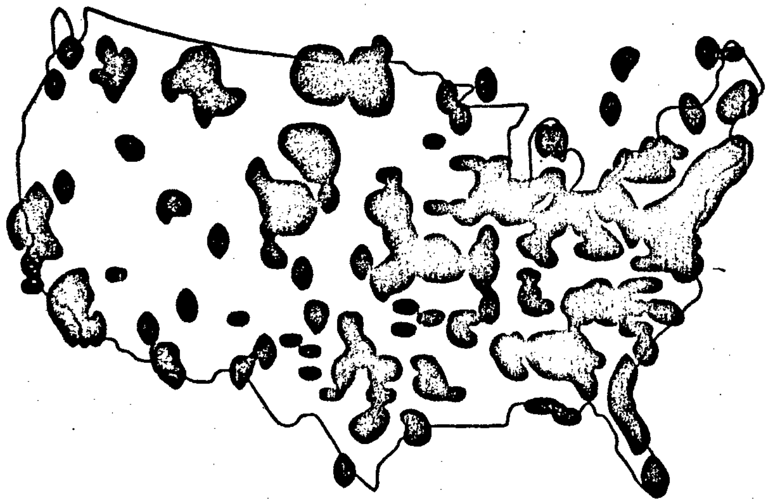


3-D DUST ENVIRONMENTS FOLLOWING SURFACE AND NEAR SURFACE NUCLEAR DETONATIONS

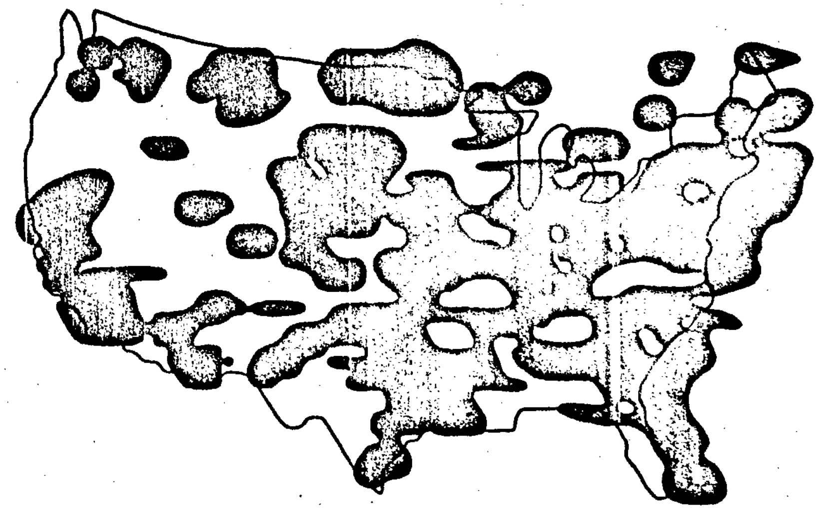


- THOUGHTS INSPIRED BY NUCLEAR CLOUD STUDY AND MT. ST. HELENS ERUPTIONS
- UP TO 1/3 MT OF DIRT LOFTED PER MT WEAPON YIELD
- PARTICLE SEDIMENTATION RATES AND LOCATIONS DETERMINED BY PARTICLE SIZES AND WINDS
- MT. ST. HELENS EXPERIENCES SHOW POTENTIAL FOR SEVERE DAMAGE TO AIRCRAFT FLYING, EVEN BRIEFLY, THRU DUST CLOUDS
- DAMAGE POTENTIAL AND MITIGATION TECHNIQUES NEED TO BE EXAMINED

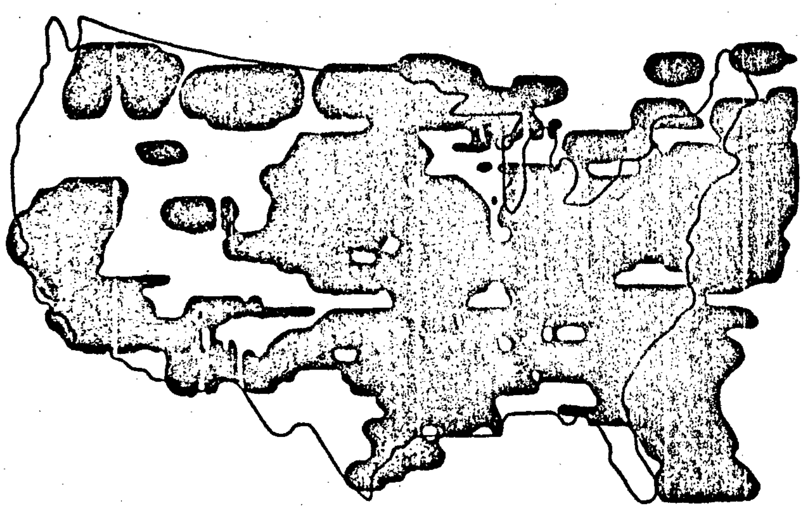
15 MINUTES



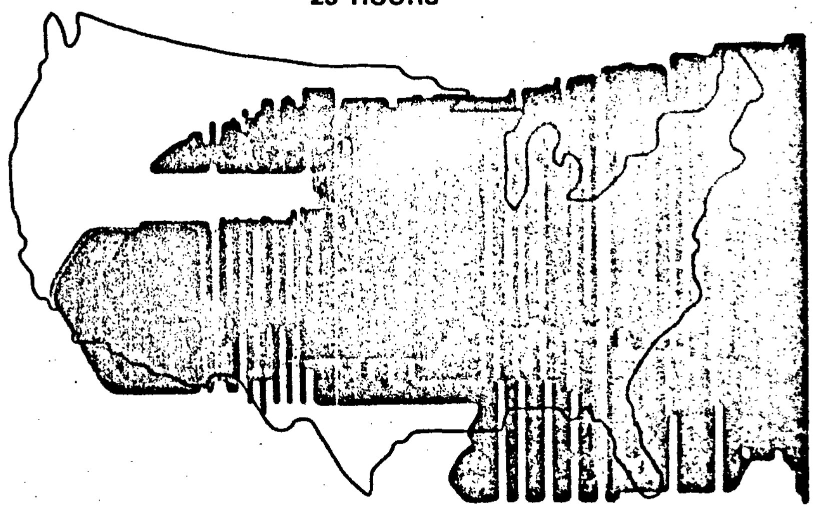
2 HOURS



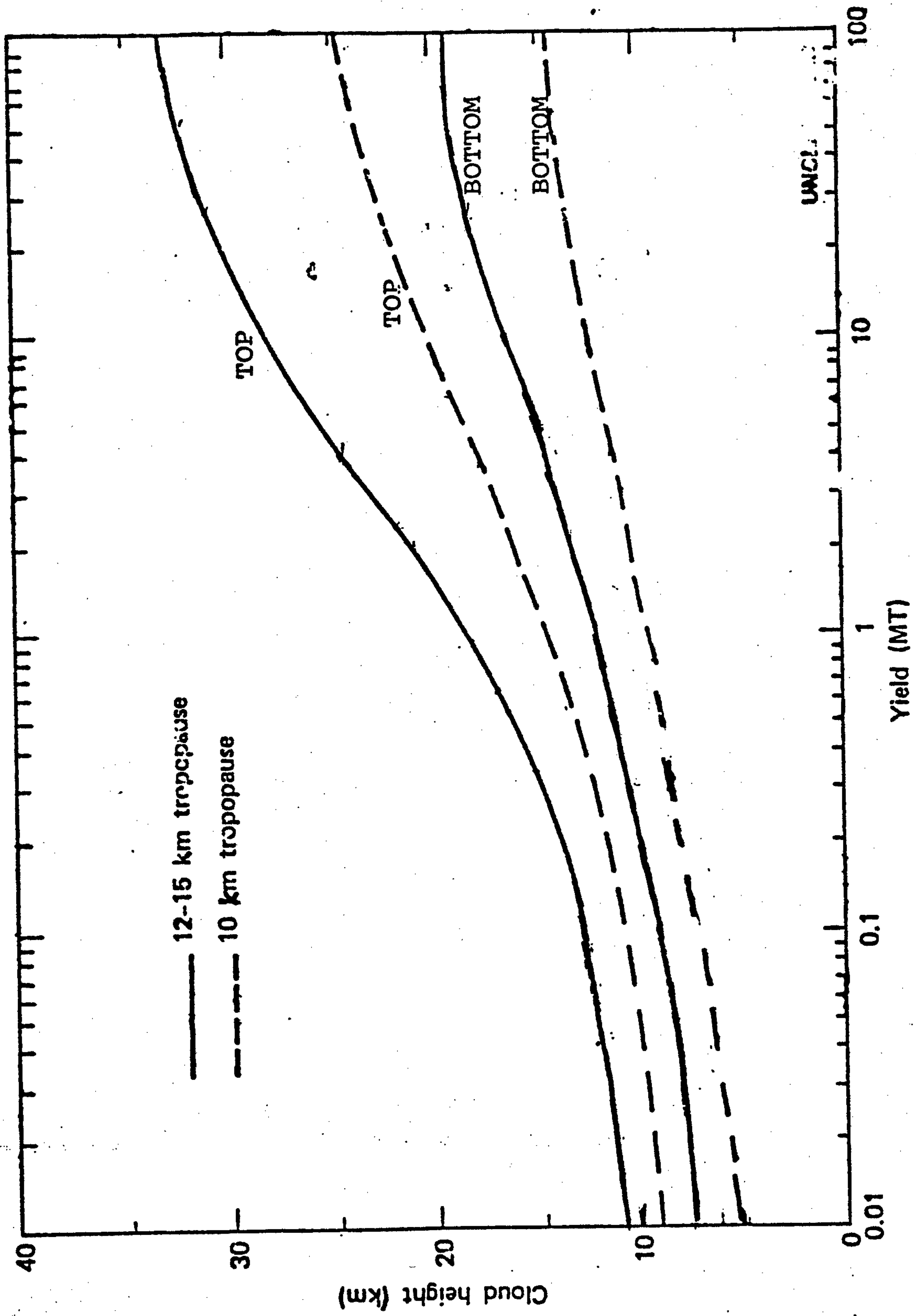
4 HOURS

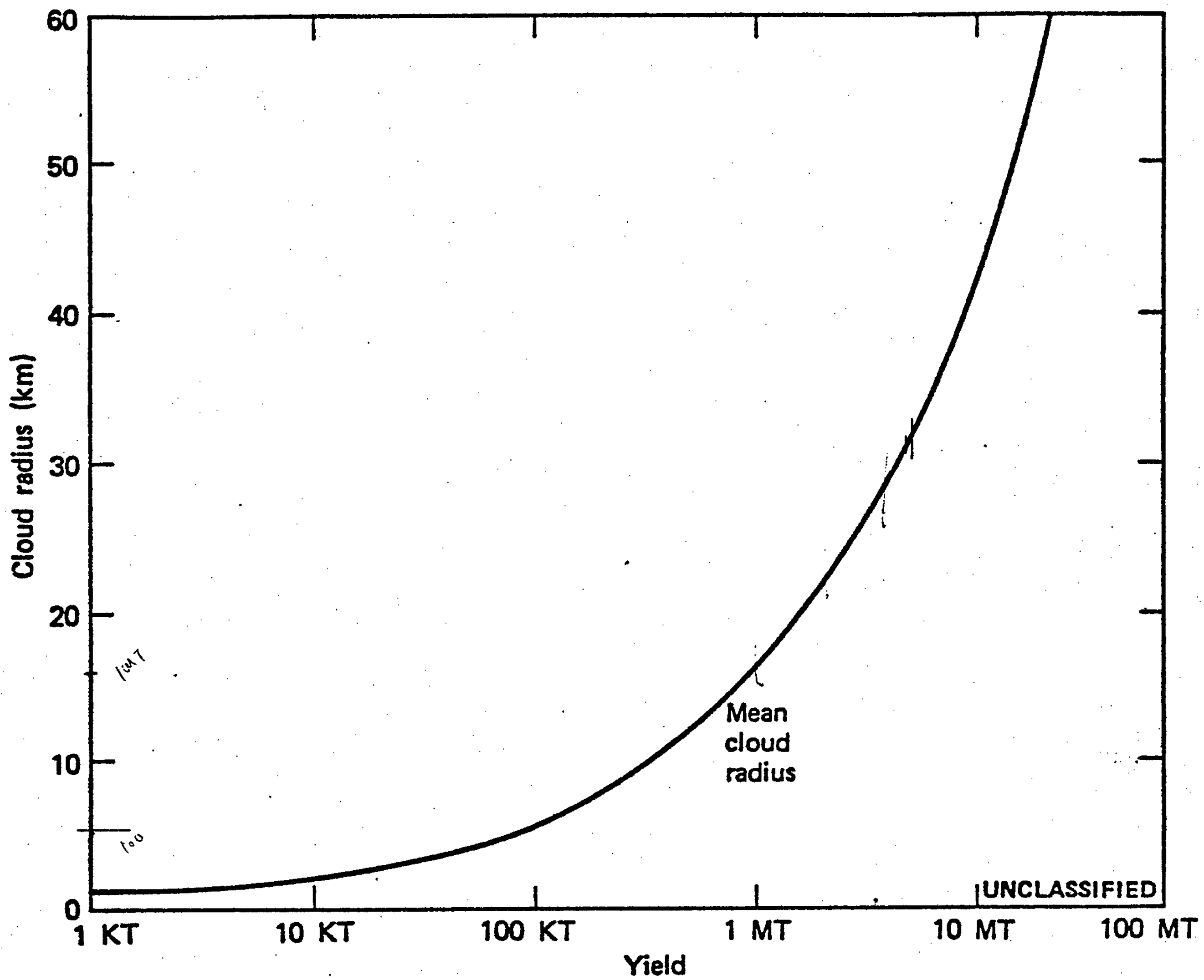


25 HOURS



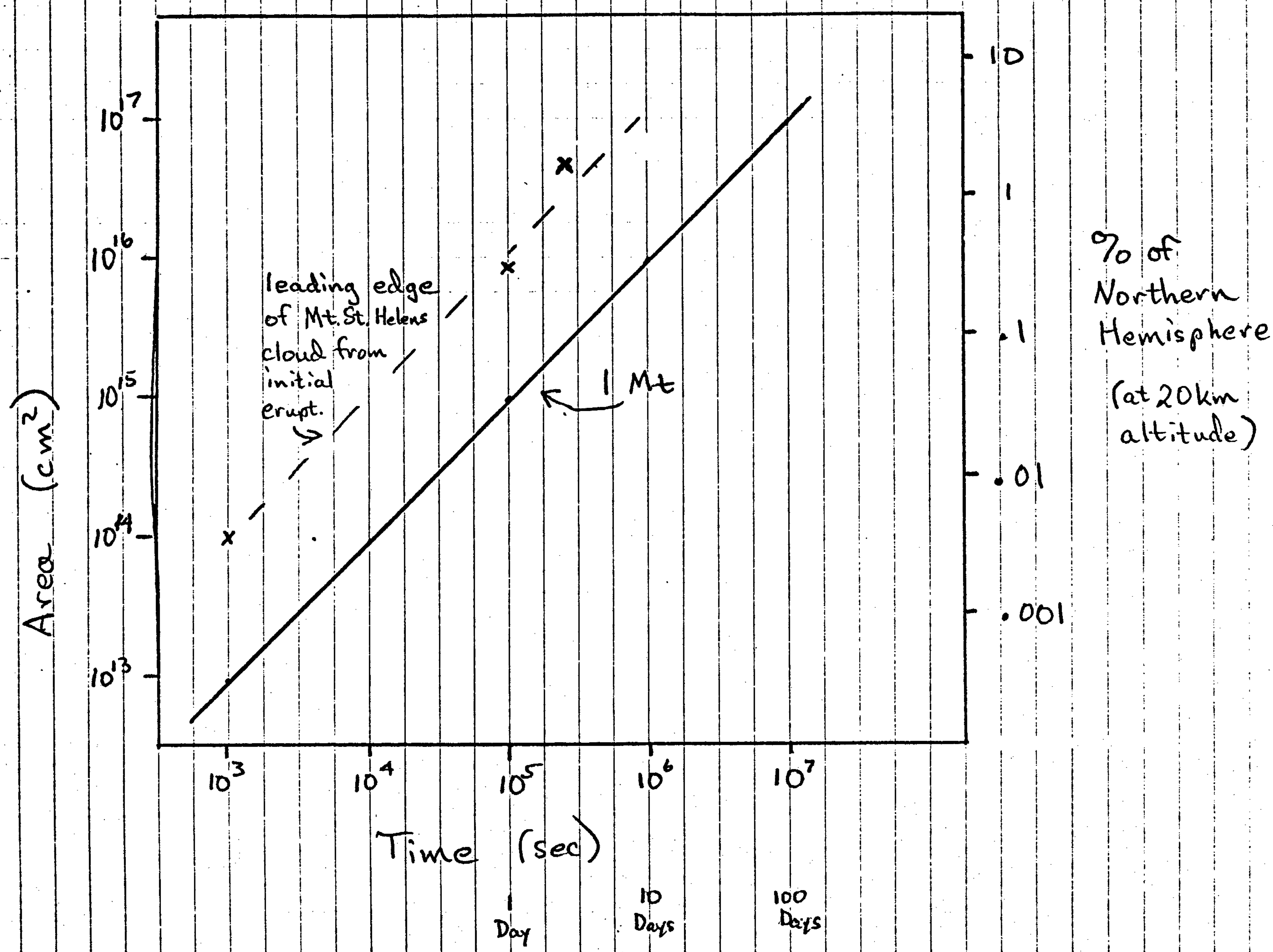
CLOUD HEIGHT VS. YIELD





(U) Low-altitude burst cloud mean radius vs yield at ~~stabilization~~ ~~time.~~ 10^3 sec

1 Mt Late-Time Cloud Area

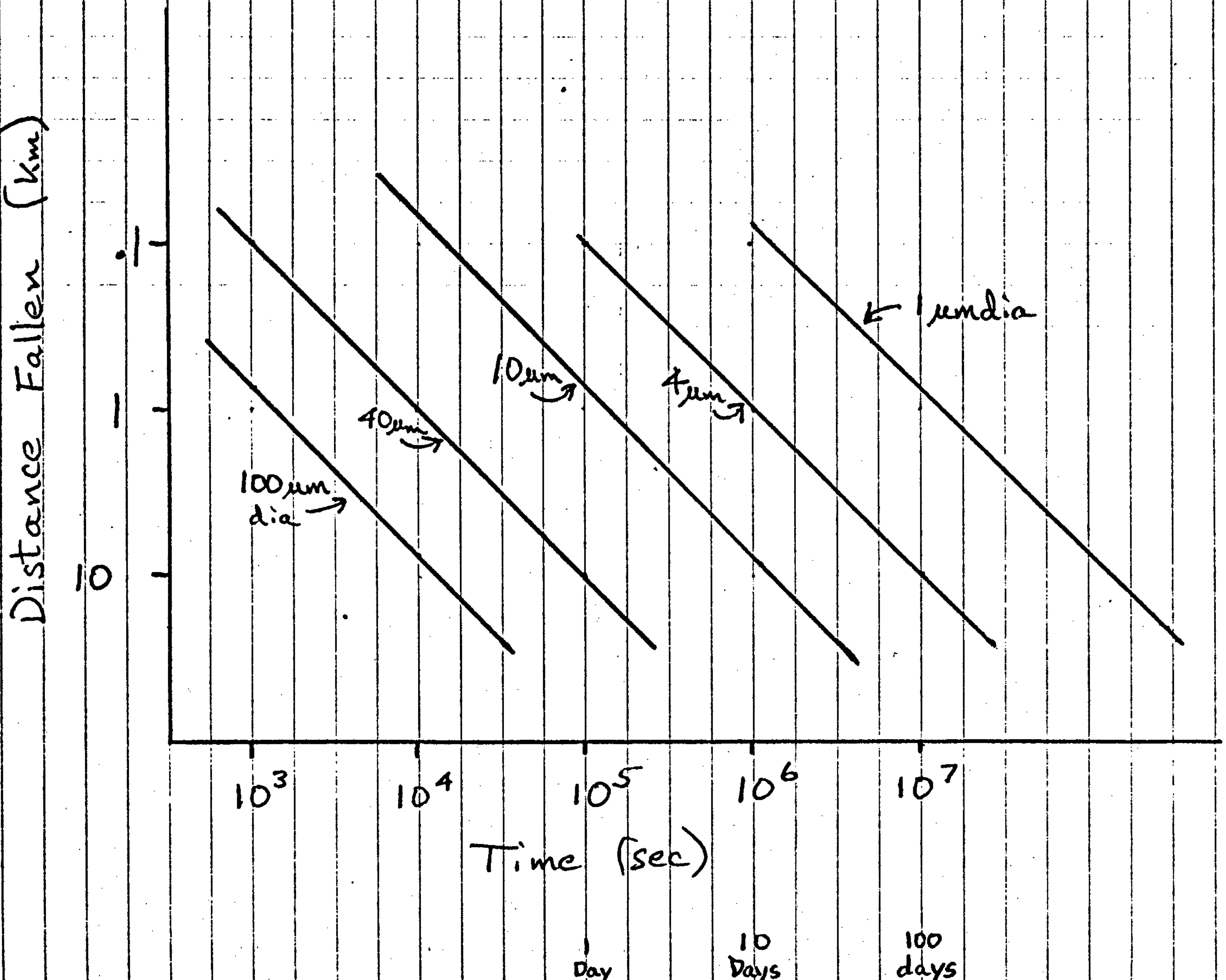


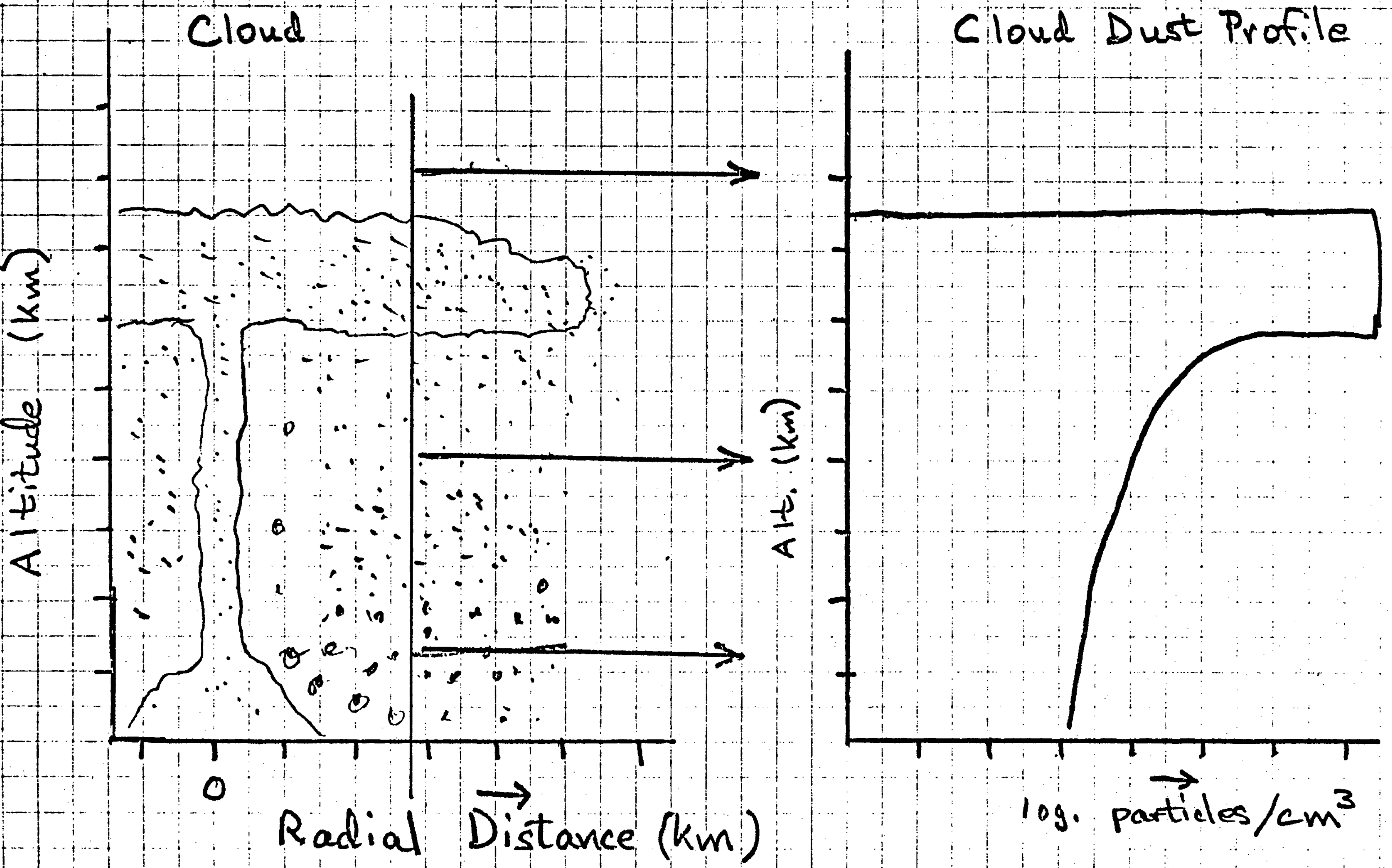
ASSUMED INITIAL DUST SIZE DISTRIBUTION*

MEAN DIAMETER	PERCENT BY WEIGHT	NUMBER/MT (DENS = 1.8 G/CM^3)	FALL RATE (CM/SEC)
0.1 μM AND LESS	10	3.2×10^{25}	6×10^{-4}
0.3 μM	10	1.2×10^{24}	2×10^{-3}
1 μM	10	3.2×10^{22}	1.2×10^{-2}
3 μM	10	1.2×10^{21}	6×10^{-2}
10 μM	10	3.2×10^{19}	6×10^{-1}
30 μM	10	1.2×10^{18}	6
100 μM	6	1.9×10^{16}	60
300 μM.	6	7.1×10^{14}	340
1 MM	6	1.9×10^{13}	1000
3 MM	6	7.1×10^{11}	2000
1 CM	6	1.9×10^{10}	4000
3 CM AND GREATER	10	1.2×10^{9}	>4000

*DUST DENSITY ASSUMED TO BE 1.8 G/CM^3

Particle Fall Rates

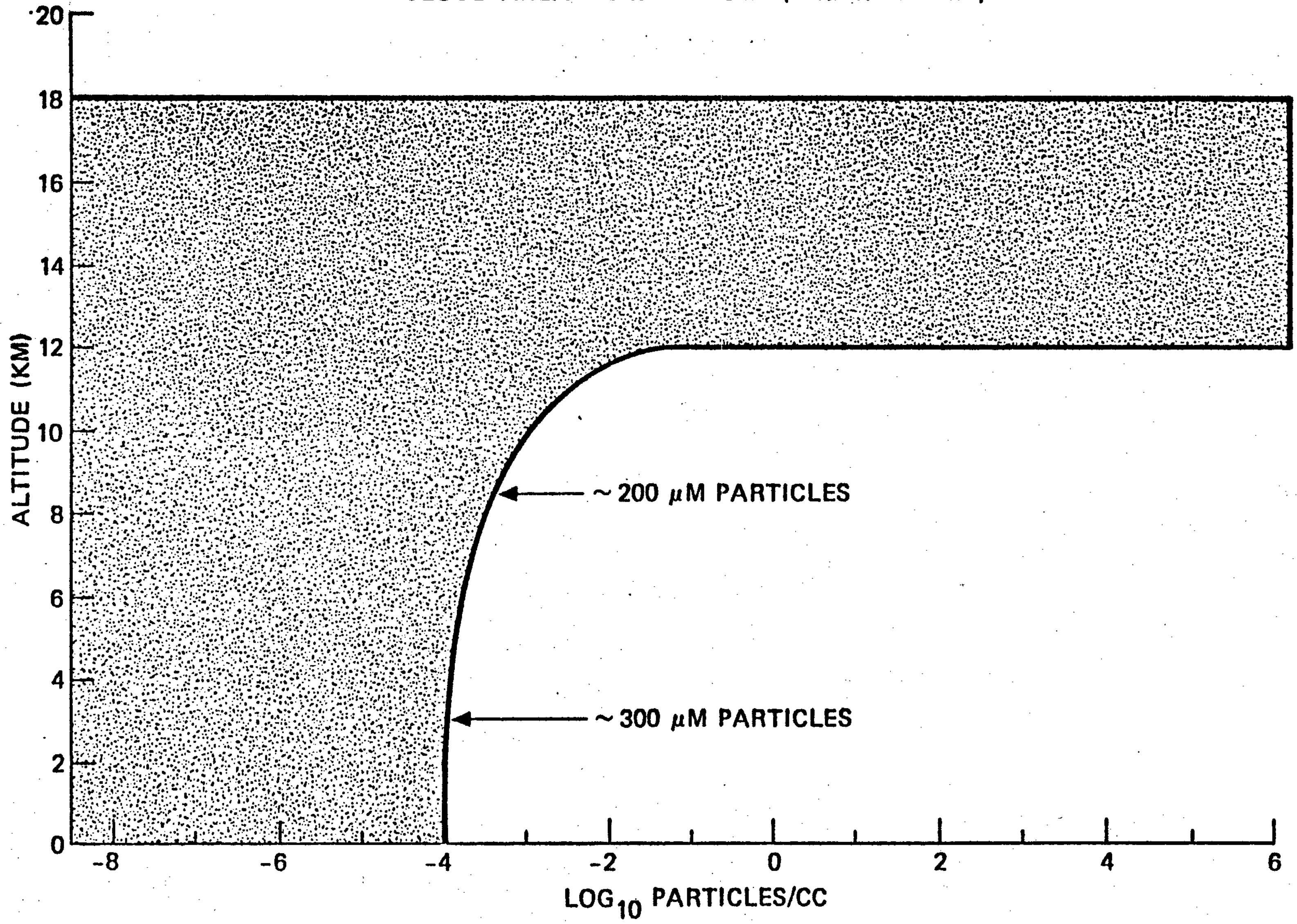




Cloud
Altitude (km)
0
Radial Distance (km)
Cloud Dust Profile
Alt. (km)
log. particles/cm³

CLOUD-DUST PROFILE
(1 MT AT 1 HOUR)

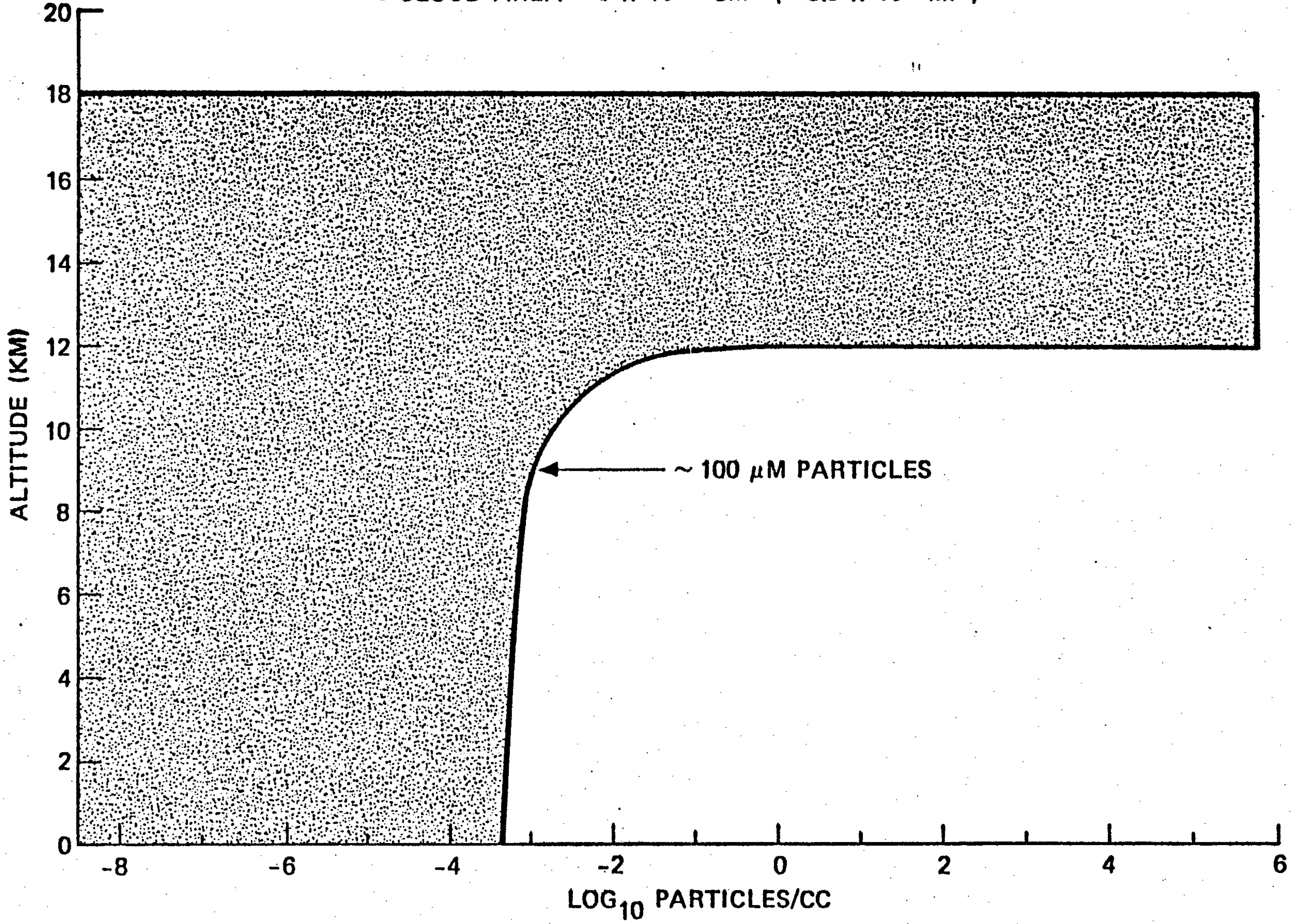
- **CLOUD AREA $\sim 3 \times 10^{13}$ CM^2 ($\sim 1.2 \times 10^3$ MI^2)**



ALL PARTICLES > 500 μM HAVE HIT GROUND

CLOUD-DUST PROFILE
(1 MT AT 3 HOURS)

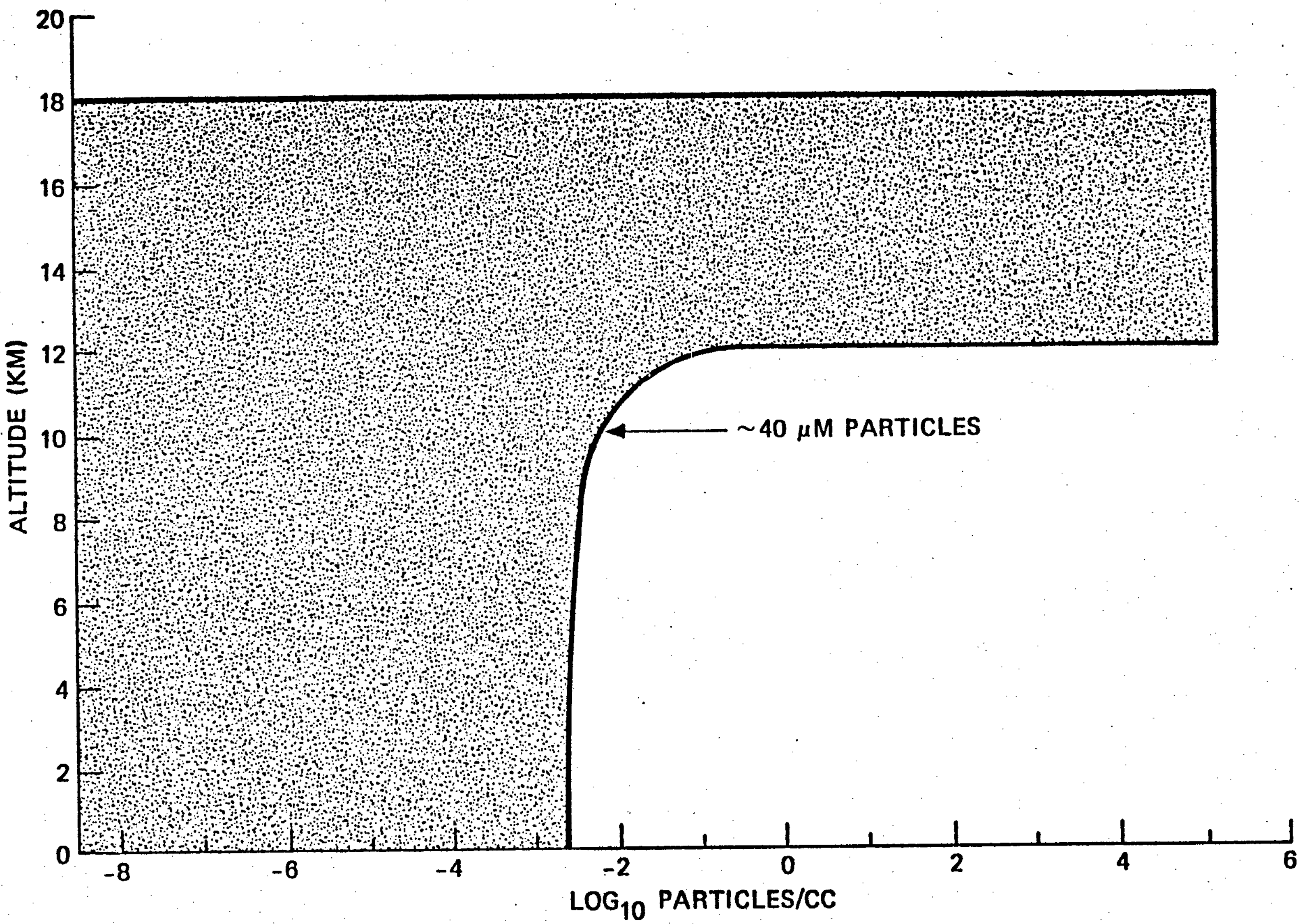
- CLOUD AREA $\sim 9 \times 10^{13}$ CM^2 ($\sim 3.5 \times 10^3$ MI^2)



ALL PARTICLES > 200 μM HAVE HIT GROUND

CLOUD-DUST PROFILE
(1 MT AT 10 HOURS)

- CLOUD AREA $\sim 3 \times 10^{14}$ CM^2 ($\sim 1.2 \times 10^4$ MI^2)



ALL PARTICLES > 100 μM HAVE HIT GROUND

INGESTION RATES (1 MT SURFACE DETONATION)
A/C AT 10 KM

ASSUME: JT3D ENGINE $\sim 1.5 \times 10^4$ CM^2 (16 FT^2)
(EC-135; B-52H)
SPEED - 3.1×10^4 CM/SEC (600 KT GROUND SPEED)

TIME	PARTICLE INGESTION RATE (PARTICLES/SEC)	G/SEC	LB/HR	MEAN PARTICLE SIZE (MICRONS)
15 MIN	4×10^4	60	470	~ 600
1 HR	5×10^5	20	160	~ 180
3 HRS	7×10^5	6	45	~ 100
10 HRS	3×10^6	1.4	10	~ 40

This page was in the original briefing and formed the basis of the idea that the LB/HR shown would be a signifigant threat to strategic aircraft. It has been superceded by the following page which shows much lower levels for LB/HR.

INGESTION RATES (SINGLE 1MT SURFACE DETONATION)

A/C @ 10 KM

ASSUME JT3D ENGINE $1.5 \times 10^4 m^2$ ($16 ft^2$) (EC135, B-52H)

SPEED 3.1×10^4 cm/sec (600 kt Gnd Speed)

TIME	MEAN PARTICLE SIZE (MICRONS)	PARTICLE CONCENTRATION mg/m^3	mg/ft^3	PARTICLE INGESTION RATE (PARTICLES/SEC)	GRAMS/SEC	LB/HR.
15 MIN	~600	16	.45	4×10^4	7	60
1 HOUR	~180	5.5	.16	5×10^5	2.5	20
3 HOURS	~100	1.5	.04	7×10^5	.7	6
10 HOURS	~ 40	.4	.01	3×10^6	.2	1
1 DAY	~ 30	.2	4×10^{-3}	3×10^6	.07	.6

Mt St. Helens early time $30 mg/m^3$ ($.85 mg/ft^3$)

~1 day $11 \mu g/m^3$

Normal at ~10 km $2 \mu g/m^3$

EXPERIENCES FROM MT. ST. HELENS

• NASA U-2	(J-57)	–	FLIGHTS AT HIGH ALTITUDE (60 KFT), AT ONE DAY AFTER INITIAL ERUPTION – NO PROBLEM
• H.A.W. DC-9	(JT-7D)	–	35 KFT, AT ~3 HR AFTER INITIAL ERUPTION – WIND SCREEN ABRASION, LEADING EDGE ABRASION, TURBINE ABRASION, OIL CONTAMINATION FOLLOWING 3-4 MIN EXPOSURE
• 2 - 727s	(JT-7D)	–	BOTH SUFFERED SEIZURE OF MIDSPAN SHROUDS IN ALL 3 ENGINES – ONE HAD ABRADED FAN BLADES IN ALL 3 ENGINES – ALL REPLACED
• RESCUE HELICOPTERS	(?)	–	ALL RESCUE HELICOPTERS HAD FILTERED ENGINES AND HAD FREQUENT (DAILY) WASHOUTS, OIL CHANGES, FILTER CHANGES – NO PROBLEMS
• T.A. L-100 (ELECTRA)	(ALLISON) 501-D22A	–	TWO ENGINES STOPPED IN FLIGHT; REMAINING ENGINES LOST POWER – WING AND WIND SCREEN ABRASION AFTER 4-5 MIN EXPOSURE 3 HOURS AFTER EVENT – 3 ENGINES WERE TOTALLY DESTROYED – 4th UNUSABLE

3-D DUST ENVIRONMENTS FOLLOWING NUCLEAR EXCHANGE

SUMMARY

- LARGE AREAS OF U.S. ARE IMPACTED
- DUST FALLING OUT FROM SURFACE AND NEAR SURFACE NUCLEAR DETONATIONS MAY PRESENT A HARSH, OPERATIONALLY LIMITING, ENVIRONMENT FOR AIRCRAFT
- PRELIMINARY ENVIRONMENTAL DESCRIPTION SHOULD BE REFINED
- ENGINE/AIRFRAME RESPONSE TO ENVIRONMENT NEEDS QUANTIFICATION
- MECHANICAL AND OR OPERATIONAL MITIGANTS ARE PROBABLY REQUIRED